The state of the environment: water quality

February 2018

Chair's foreword

Water keeps us alive, drives our economy and sustains wildlife. Having good water quality, managed in a way that makes sure the country is more resilient to flood and drought, is essential.

As the environmental regulator the Environment Agency needs to understand the complex natural and man-made systems that allow people to water crops, wash cars, take showers and drink healthy tap water wherever they live in England. This means close partnership working with water companies, farmers, businesses and environmental organisations.

Over the last 30 years, there has been good progress following more than a century of poorly regulated industrial practices. England has the cleanest bathing waters since records began, serious pollution incidents are steadily declining and rivers that were biologically dead are reviving.

Today, the environment we live and work in faces new challenges. Climate change is causing more extreme weather, extended periods of drought punctuated by more intense rainfall events are set to become increasingly normal. It’s time to redouble our efforts.

There are still far too many serious pollution incidents, 317 to water in 2016. Unacceptable levels of phosphorus in over half of English rivers, usually due to sewage effluent and pollution from farm land, chokes wildlife as algal blooms use up their oxygen. Groundwater quality is currently deteriorating. This vital source of drinking water is often heavily polluted with nitrates, mainly from agriculture. Water companies then have to treat water from different sources to make it safe to drink.

Our ambition is a cleaner, healthier and better managed water environment. Defra’s 25-year environment plan challenges us to improve at least three quarters of our waters to be close to their natural state. Everyone has a part to play:

- the public and businesses must do more to keep plastics, fats and household chemicals out of our drains
- water companies must continue reducing pollution incidents from sewer systems and sewage treatment works
- farmers must manage their land responsibly, using fertilisers and pesticides with much greater care – all the more so as the government considers new payments that increasingly reward environmental and public benefits
- we need water companies, businesses and volunteers to provide practical and financial support for our catchment partnerships to help rejuvenate our water environment
- the Environment Agency will work closely with others to make this happen, but we won’t hesitate to prosecute when necessary. We will put things right quickly through voluntary Enforcement Undertakings for minor breaches, but the size of fines for more serious offending needs to be proportionate to turnover and consistently applied by the courts. Company boards have to take environmental risk seriously and not see it as an operational expense

This report provides an assessment of water quality in England and the pressures it faces. Improving it remains one of the Environment Agency's biggest and most important tasks. We can only do this by working in partnership across all sectors and society.

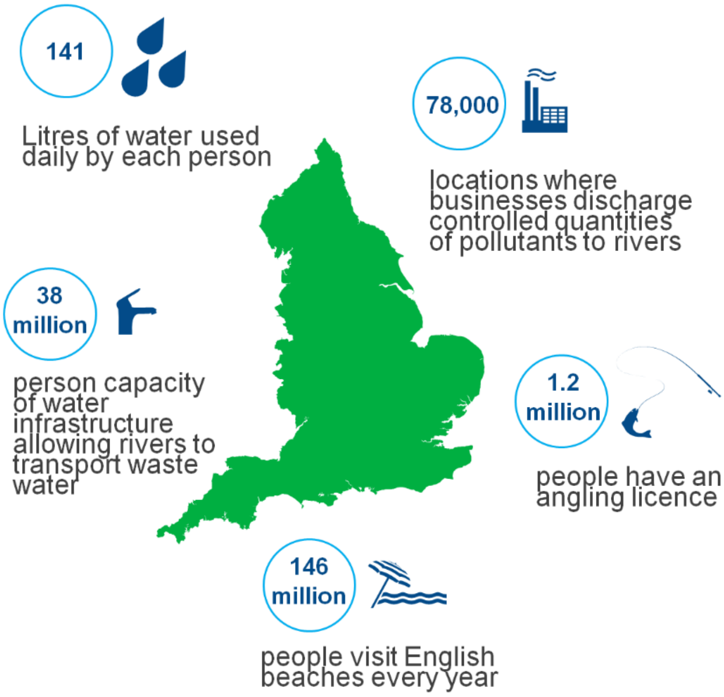
Emma Howard Boyd, Chair of the Environment Agency

Key findings

- In 2016, 86% of river water bodies had not reached good ecological status. The main reasons for this are agriculture and rural land management, the water industry, and urban and transport pressures.
- Water quality issues were the cause of 38% of all fish test failures, and 61% of invertebrate test failures in rivers in 2015.
- Pollutant loads to rivers from water industry discharges have declined in recent years, with reductions of up to 70% since 1995.
- Over the last decade the number of serious water pollution incidents from water companies has remained broadly the same, with about 60 incidents each year. That is more than one a week.
- For assessed river water bodies in England, 55% were at less than good status for phosphorus in 2016.
- Nearly half of groundwater bodies will not reach good chemical status by 2021. For groundwaters protected for drinking water, nitrate levels were responsible for 65% of failures to achieve good chemical status.
- Bathing water quality has improved over the last 30 years with 98% passing minimum standards and 65% at excellent status in 2017.
- Population growth, climate change, emerging chemicals, plastic pollution, nano-particles and fracking all present potential future threats to water quality.

Water use in England

Water provides people and wildlife with a wide range of services. It's used for drinking,[1] transporting household and industrial waste, and for recreational activities such as swimming and angling. The Office for National Statistics estimates the value of freshwaters for the whole of the UK at £39.5 billion.[2]



Our role

The Environment Agency:

- has taken over 50 million water quality samples since 1998
- works in partnership with a wide range of organisations, and takes action to improve water quality by targeting point and diffuse sources of water pollution

Where we want to be

Work is underway to achieve the environmental objectives set out in our 2015 river basin management plans. There is still work to do to achieve the planned improvements to surface waters by 2021, but projections suggest that we will meet them (table 1).

Good groundwater body status will be reached by 2021 in 75% of bodies for quantitative status and 56% of bodies for chemical status.

Table 1

Percentage of surface water bodies at good or better ecological status in 2016 and planned improvements by 2021

Water body	2016	2021
Rivers	14% (76%)	21%
Lakes	16% (56%)	19%
Coasts	45% (87%)	53%
Estuaries	20% (77%)	25%

Note: Numbers in brackets show % of individual tests achieving good or better status and may give a better indication of water body condition.

[1] Discover Water. (2018) https://discoverwater.co.uk/amount-we-use
[2] Office for National Statistics. (2017) UK natural capital: ecosystem accounts for freshwater, farmland and woodland. https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/landandhabitatecosystemaccounts#ecosystem-accounts-for-freshwater

Status and trends: ecological status of rivers

Water quality in rivers has improved markedly in recent decades (figure 1), but these improvements have not continued in recent years. There was a 1% decline in the number of rivers that were at 'good or better' biological or chemical status in 2016 compared to 2015 (figure 2). 'Good or better status' means that a water body is close to 'undisturbed' conditions.

Figure 1

Rivers achieving good or better biological or chemical quality, 1990 to 2008

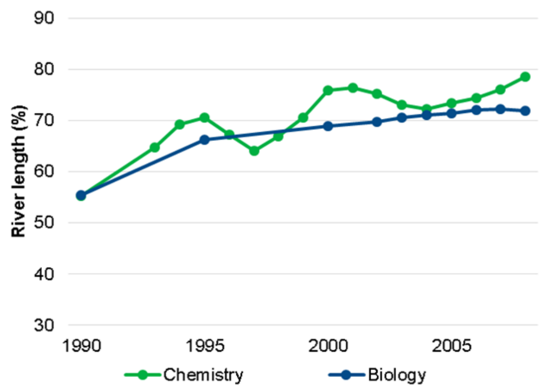
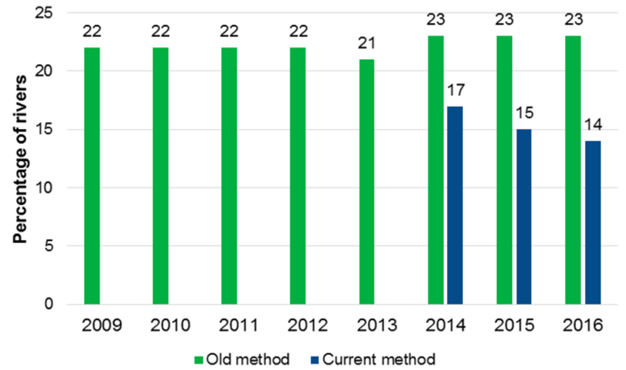


Figure 2

Rivers achieving good or better ecological status 2009 to 2016



Note: Assessment method changed in 2014

Ecological status

The ecological status of a water body is assigned using information from biological and physico-chemical (for example oxygen levels) testing, as well as the degree to which humans have modified its flow and structure.

Biological, chemical and ecological status are assigned[3] using various water quality tests. Failure of one test means that the whole water body fails to obtain good or better status. The evidence base for status classifications was upgraded in 2014. This is reflected in lower numbers of rivers achieving good or better status since then.

Ecosystem effects of water quality

Water quality can be assessed directly by measuring the concentrations of pollutants such as nutrients and chemicals. Monitoring shows that phosphorus (a nutrient) was the most common reason for rivers not achieving good status in 2016. Of all assessed river water bodies in England, 55% were at less than good status for phosphorus.

Water quality can also be assessed indirectly by looking at the condition of aquatic plant and animal communities. Their health depends greatly on the quality of the water. For example, high levels of phosphorus can lead to excessive growth of algae and plants, choking river channels, using up oxygen at night and adversely affecting the plants, fish and invertebrates. Of all assessed river water bodies, 56% were at less than good status for water plants and algae in 2016 and phosphorus was considered the prime cause. Of all assessed rivers, 59% were at less than good status for fish, and 26% at less than good for invertebrates. Water quality issues were the cause of 38% of all fish test failures, and 61% of invertebrate test failures in rivers in 2015.

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[3] European Commission. Introduction to the new EU Water Framework Directive http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm.

Status and trends: nutrients in rivers and groundwater

Nutrients are a major cause of water bodies being at less than good ecological status and also affect drinking water quality. The main nutrients affecting water quality in England are phosphorus and nitrates.

Figure 3

Total reactive phosphorus concentrations in the rivers Thames and Lee 1932 to 2012

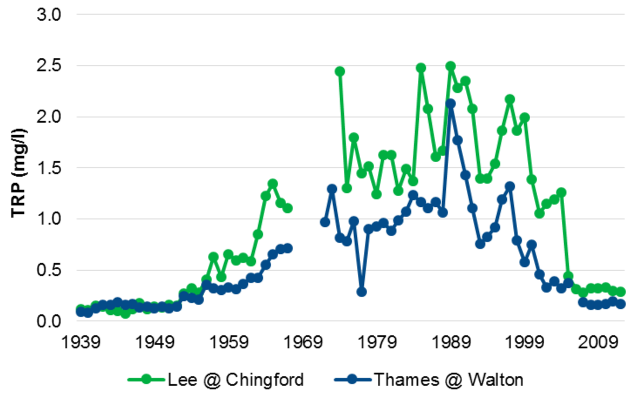
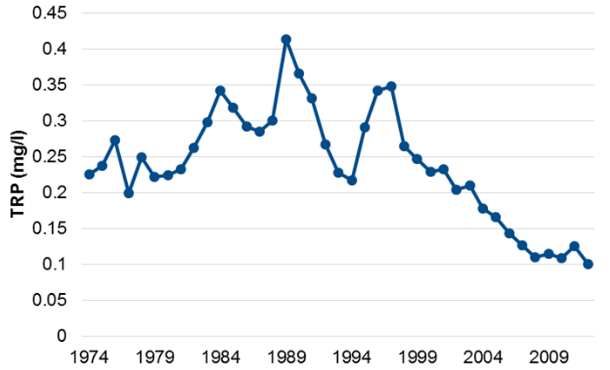


Figure 4

Annual average concentration of total reactive phosphorus in rivers, 1974 to 2012



Phosphorus in rivers

Phosphorus is the top reason for English water bodies not achieving good ecological status. It's the main cause of eutrophication in England's rivers (and lakes). High phosphorus concentrations cause excessive algal and plant growth which damages the ecology, quality and uses of waters. The main sources of phosphorus in rivers are sewage effluent and run-off from agricultural land.

Phosphorus levels in rivers increased from the 1950s to the early 1990s. The trends seen in the rivers Thames and Lee are a good illustration of changes in lowland areas over this period (figure 3). Phosphorus levels in rivers started to reduce in the mid-1990s and have been decreasing significantly since then (figure 4). [4] This decrease is closely associated with improvements at sewage treatment works.

Nitrates in rivers

Nitrates are applied to agricultural land to enhance crop yields. They can be a problem for surface waters, affecting the quality of water abstracted for drinking water treatment. Nitrate levels in many rivers increased dramatically during 2 periods in the second half of the 20th Century, (figure 5). The first increase, during World War 2, was associated with mass conversion of land to arable farming, when extensive ploughing released nitrogen stored in the soil. The second, in the 1960s, was linked to further conversions to arable coupled with substantial increases in fertiliser use.[5] There have been slight declines in nitrates in rivers since 2000 (figure 6). [4]

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[4] Figure shows Harmonised Monitoring Scheme data. Analysis from: Worrall, F., Jarvie, H.P., Howden, N. J. K., Burt, T.P. (2016) The fluvial flux of total reactive and total phosphorus from the UK in the context of a national phosphorus budget: comparing UK river fluxes with phosphorus trade imports and exports. Biogeochemistry 130: 31-51.

[5] Burt, T. P.; Howden, N. J. K., Worrall, F., Whelan, M. J., Bieroza, M. (2011) Nitrate in United Kingdom rivers: policy and its outcomes since 1970. Environmental Science and Technology 45: 175-181

Figure 5

Nitrate concentration in the River Thames 1868 to 2014

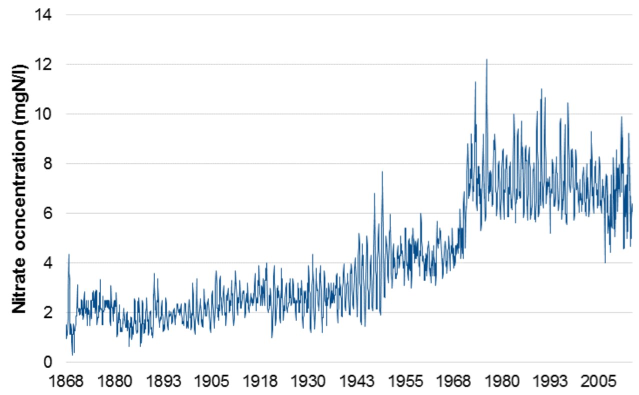
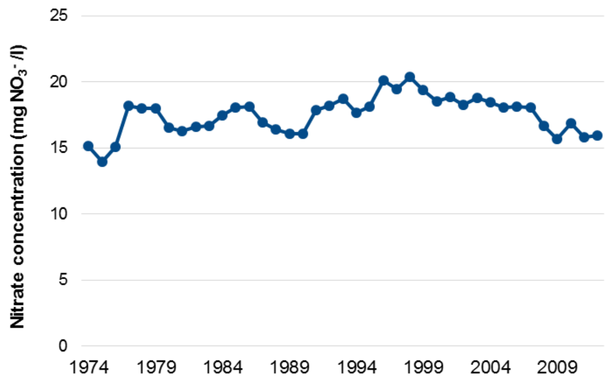


Figure 6

Annual average concentration of nitrate in rivers 1974 to 2012



Nitrates in groundwaters

Groundwaters are a vital part of England's drinking water resources. They supply around 30% of the country's drinking water.[6] Groundwaters have been deteriorating in quality over the last 60 years. Only 53% achieved good chemical status in 2016. Nitrates are a major issue and can cause exceedance of drinking water quality standards. Nitrates account for 65% of the reasons for failure for those groundwaters that are protected for use for drinking water and are classed at poor status. Nitrate enters groundwater from diffuse pollution on land (mainly water run-off from agricultural land) or is deposited onto land from the air. Modelling suggests in rural areas of the UK more than 80% of nitrate in groundwater comes from agriculture. For most British aquifers it will travel through the unsaturated rock and reach the water table within 20 years. In some places it can take much longer. The groundwater nitrate levels in those locations are predicted to continue to rise for up to 60 years as the 1980 to 1990 peak in land nitrate applications reaches the water table.

Action 1

Farmers: Adopt the government’s new farming rules for water and use fertilisers and manures with greater care and manage land better to minimise pollution incidents and nutrient losses to water.

Water companies: Continue to improve wastewater treatment processes to reduce nutrient impacts on water.

Status and trends: chemicals in rivers and groundwater

A vast range of chemicals are used every day, both at home and in workplaces. Some of these can adversely affect the environment. Many of these substances come from using products in homes, hotels, restaurants, offices and industry and get into the water environment via sewers and sewage treatment works. Other sources of chemicals are released directly to the water environment, such as from industry

[6] UK Groundwater Forum. FAQs. http://www.groundwateruk.org/Is-The-Water-in-my-tap-groundwater.aspx

and run-off from roads and farmland. Some substances are already widespread in the environment as a result of past use that has contaminated land and sediment. In addition, historic industrial activity such as mining has led to significant emissions of metals from below the ground into the water environment.

Chemicals in rivers

A range of chemicals can be locally significant influences on water quality. Substances more often found in rivers at levels exceeding their environmental quality standard in water include metals such as cadmium, lead, nickel and zinc and the organo-metal tributyl tin. Recent data suggests the pesticide cypermethrin may exceed more stringent environmental quality standards due to be introduced from 2018. Elevated levels of plant protection products such as metaldehyde can be problematic for drinking water abstractions. We do not have long-term trend data for many of these chemicals because the places where they are monitored have changed over time. Some chemicals can accumulate in food chains, threatening the health of ecosystems. Exposure to low levels of some chemicals in water can cause disruption of endocrine functions, such as reproduction, in animals.[7] Examples of endocrine disruptors are certain pesticides, and some pharmaceuticals.

Until recently, assessing chemical status of water bodies was based entirely on monitoring of water samples. While this remains the case for most substances, samples from the flesh of aquatic biota such as fish or mussels are beginning to be used for certain substances that can accumulate in food chains. As a result of these changes in assessment, significant and widespread failures of chemical standards in biota are predicted for some banned or highly regulated chemicals. This is notable for mercury and the brominated flame retardants polybromodiphenyl ethers (PBDEs), and to a lesser extent certain per-fluorinated chemicals such as: perfluoro-octyl-sulphonate (PFOS); dioxins and dioxin-like polychlorinated biphenyls (PCBs); and occasionally hexabromocyclododecane (HBCDD). Polyaromatic hydrocarbons (PAHs) that arise from combustion are often found at elevated levels in the water column but may not be preferentially taken up by biota.

[7] U.S. Geological Survey. Tackling fish endocrine disruption. https://toxics.usgs.gov/highlights/fish_endocrine_disruption.html

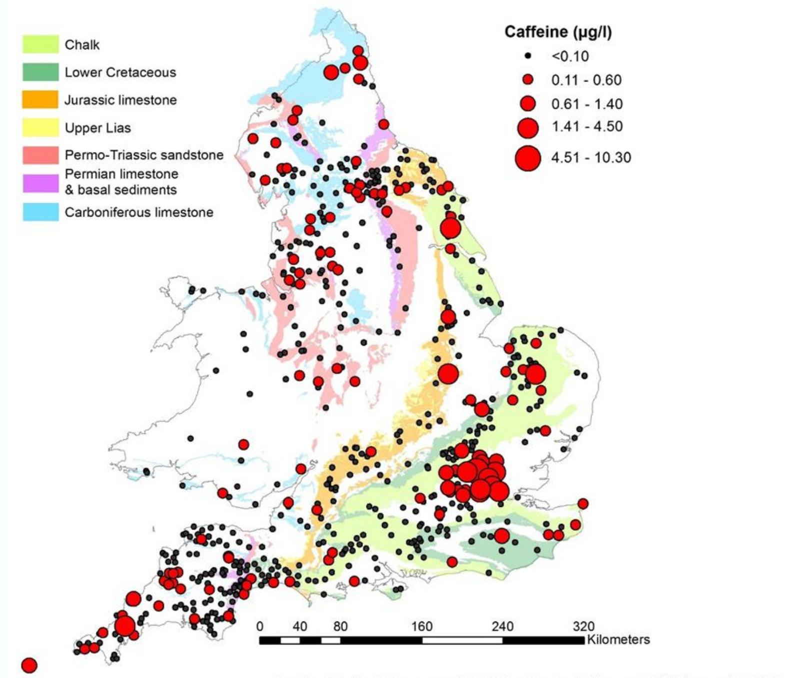
Chemicals in groundwaters

Chemicals from industrial and agricultural sources contaminate many groundwaters. Pesticides are one of the more common groups of chemicals found. Many other chemicals are also finding their way into groundwaters. For example, caffeine, thought to originate from leaking septic tanks and sewage pipes, is now found at large numbers of groundwater sites across the country (figure 7). Although caffeine is not known to be harmful to humans or the environment, this demonstrates the pervasive effects of human activity on groundwaters.[8]

Figure 7

Caffeine concentrations in groundwater, 2012

Source: British Geological Survey



Action 2

Water companies: Understand the range of chemicals in sewerage systems and how they may be controlled.

Public: Minimise the use of household chemicals and pesticides and dispose of them responsibly.

Farmers: Use pesticides with greater care to prevent run-off to water.

Status and trends: coastal areas

Bathing waters have shown an improving trend in quality over the last 30 years or so (figure 8), with 98.3% passing minimum standards and 65.4% at excellent status in 2017. This is nearly as good as the record high results of 2016 despite the wetter summer.

Eutrophication caused by excess nitrate can be a problem in estuaries and coastal waters. Sixteen coastal and estuarine water bodies are designated as affected by eutrophication. These are mostly shallow harbours. Levels of nutrients and other pollutants entering estuaries from rivers tend to vary with the levels of river flow, so interpreting trends over time can be difficult. Data suggests that nitrate and metal levels

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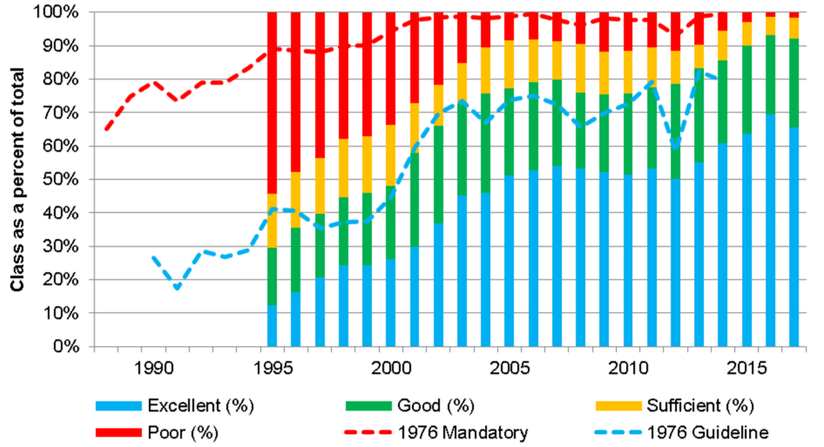
[8] British Geological Survey. (2011) Science Briefing: Emerging Contaminants in Groundwater. http://www.bgs.ac.uk/research/groundwater/quality/emerging_contaminants.html

have remained relatively steady over the last 15 years, whereas phosphates have reduced to less than half of their 1998 level.

Radioactive substances are discharged into coastal waters from nuclear facilities under permit, and are sometimes present at low levels in shoreline seawater and coastal sediments. Radionuclides from past discharges may be remobilised from sediments, providing an on-going source to shoreline seawater and coastal sediments. Where trend data is available, for example around Sellafield, levels of radioactive substances have shown dramatic declines over the past 30 years.[9]

Figure 8

Trend in bathing water classification 1995 to 2017 (with comparison to historic data)



Current pressures

Pressures affecting water quality include:

- diffuse pollution from towns, cities, transport and rural areas
- pollution from waste water
- run-off from abandoned mines

Pressure sources

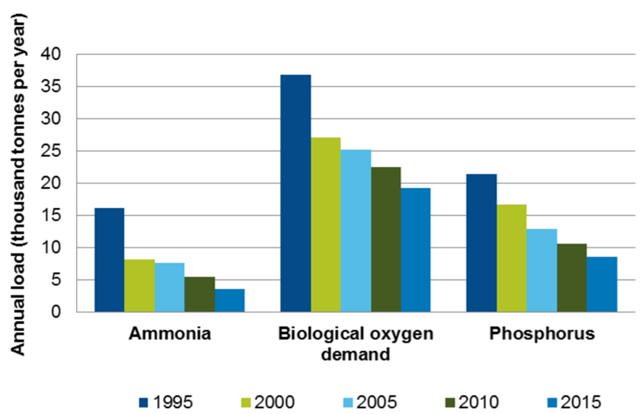
Many human activities put pressure on water quality. The main activities that prevent water bodies reaching good status are:

- agriculture and rural land management (31% of reasons for water bodies not achieving good status)
- the water industry (28%)
- urban and transport (13%)

Pollutant loads to rivers from water industry discharges have declined in recent years, with 40% to 70% reductions since 1995 (figure 9).

Figure 9

Pollutant loads to rivers from the water industry 1995 to 2015



[9] Centre for Environment, Fisheries and Aquaculture Science (CEFAS). (2016) 'RIFE 22. Radioactivity in Food and the Environment'. https://www.gov.uk/government/publications/radioactivity-in-food-and-the-environment-rife-reports

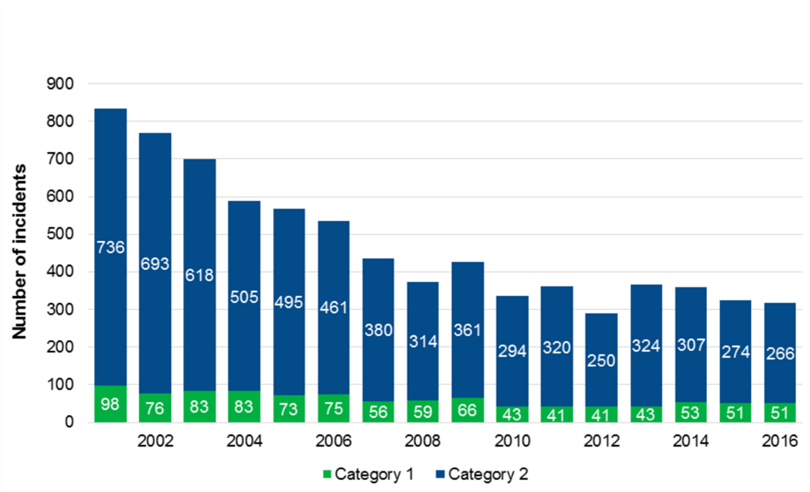
Pollution incidents

Agriculture is now the largest sector responsible for significant pollution events to water. Pollution incidents can have devastating effects on wildlife and can endanger human health. The overall number of water pollution incidents has, however, reduced in recent years. The number of serious incidents (category 1) fell by almost two-thirds between 2001 and 2016 (figure 10).

The number of serious water pollution incidents from water companies has levelled over the last decade to about 60 incidents each year.

Figure 10

Serious water pollution incidents 2001 to 2016



Action 3

Farmers: Manage farming practices better to reduce pollution incidents.

Water companies: Reduce pollution incidents from sewer systems and sewage treatment works.

Public and business: Keep fats oils greases and household chemicals out of our drains.

Future pressures

Population pressure

Increased population pressure, particularly in southern and south east England, will increase nutrient loadings. Increased phosphorus as a result of this pressure presents the most likely near-term risk of deterioration in rivers. It has been estimated to pose a risk to 2% of river water bodies in England. Increased sewage is also likely to contribute to higher levels of faecal contamination in bathing and shellfish waters. Agricultural intensification to feed a growing population may lead to increased loadings of nitrates and other agricultural pollutants to water.

Housing and industrial growth, as well as urban creep, will increase the pressures on sewerage infrastructure, increasing the frequency that sewers flood. Urban creep is where residents in urban areas install or enlarge patios, extensions and driveways, increasing the impermeable area. The impact of urban creep on the sewer system is thought to be similar in magnitude to the impact of both population growth and climate change.[10] We expect a growing and ageing population to cause increased levels of a range of pharmaceutical drugs in surface waters.

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[10] UKWIR. (2010) The impact of urban creep on sewerage systems. https://www.ukwir.org/reports/10-WM-07-14/66915/Impact-of-Urban-Creep-on-Sewerage-Systems

Climate change

Climate change is already affecting the UK. Air temperature has risen by around 1°C in England since the 1970s[11] and is expected to continue to increase. Climate change is likely to exacerbate eutrophication impacts, through increased summer temperatures, changes in rainfall patterns and reduced river flows. Increased storm run-off may lead to higher nutrient loads from land to water. Increased temperatures and sunlight, and lower summer river flows are likely to cause increased algal growth. However more frequent storms may reduce eutrophication risks.

Increased future demand for water resources, coupled with climate change, may lead to the need to use groundwater deeper below the surface. Little is known about the quality of deep groundwater sources.

Emerging chemicals

We continuously review our monitoring to include chemicals of emerging concern. Substances in surface waters that are of particular interest include the:

- insecticide, imidacloprid
- antibiotic, clarithromycin
- anti-inflammatory medicine, diclofenac
- natural and synthetic oestrogens from human and livestock populations

Combinations of chemicals may have different environmental effects than we might predict from the properties of the individual substances in the mixture. The science is at an early stage, but some studies suggest that monitoring should take these combination effects into account.

Plastic pollution

Plastic waste found in freshwaters includes large plastic items such as drinks bottles and other types of plastic packaging, and small particles known as microplastics. Microplastics are plastic particles less than 5mm in size. They enter water bodies from domestic and industrial sources, as well as from urban run-off, and also result from the breakdown of larger plastic debris.

Plastic waste is visually unappealing and can harm animals through entanglement and ingestion. Plastics can also act as a reservoir for toxic chemicals: these and plastic-breakdown products have the potential to enter the food chain and bio-accumulate in marine and freshwater life. Concerns about plastics often centre on the marine environment, but the impacts of plastic in the freshwater environment should not be overlooked. A recent study[12] found microplastics in large numbers in the river Thames and its tributaries, even in areas where little pollution would be expected. This suggests they are also widespread in freshwaters. The main sources were synthetic fabrics, packaging products and road marking paint. Microplastics were found in 72% of European drinking water samples in a small study in 2017.[13]

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[11] Met Office. (2017) State of the UK climate 2016. https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/uk-climate/state-of-the-uk-climate/mo-state-of-uk-climate-2016-v4.pdf

[12] Horton, A. A., Svendsen, C., Williams, R.J., Spurgeon, D. J., and Lahive, E. (2016) Large microplastic particles in sediments of tributaries of the River Thames, UK – Abundance, sources and methods for effective quantification. Marine Pollution Bulletin 114: pp. 218-226.

[13] Orb Media. (2017) Synthetic polymer contamination in global drinking water. https://orbmedia.org/stories/Invisibles_final_report

Nanoparticles

Nanoparticles are increasingly common in everyday items such as sunscreens and cosmetics, as well as in antifoulant boat paints. Growing numbers of studies are revealing negative effects of some nanoparticles on aquatic life.

Fracking

Fracking for shale gas could bring risks to the quality of both surface and groundwaters as well as placing a new demand on water resources in some areas. The main concerns involve accidental spills or leaks, particularly if these should occur in the subsurface. The onshore oil and gas industry has a long history in England but strong regulation around techniques such as fracking will need to continue in order to minimise such risks.[14]

Action 4

Public and business: Minimise the use of single-use plastics.

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[14] The Royal Society. (2012) Shale gas extraction in the UK: a review of hydraulic fracturing. http://www.raeng.org.uk/publications/reports/shale-gas-extraction-in-the-uk